APPLICATION OF THE LASER DOPPLER VELOCIMETER IN AERODYNAMIC FLOWS

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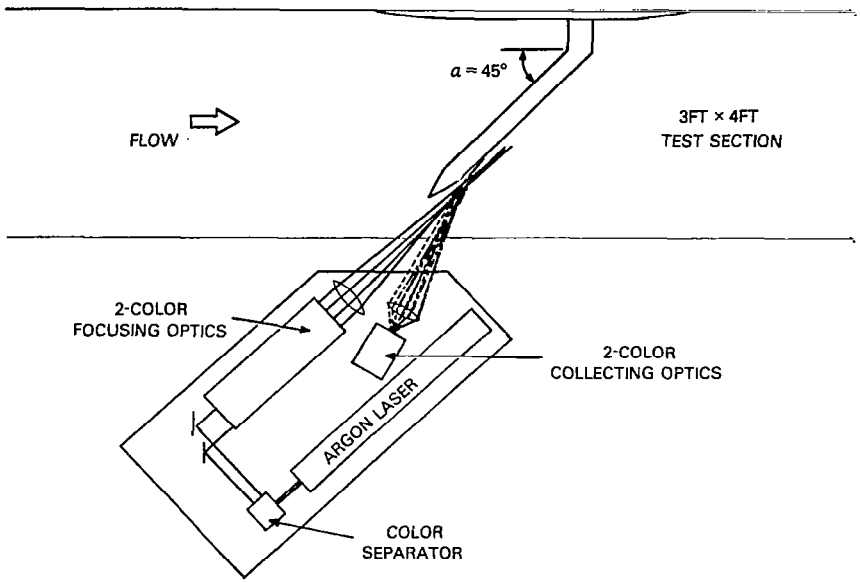
Measurements have been made of the flowfield around a tangent-ogive model in a low turbulent, incompressible flow at an incidence of 45°. The free-stream velocity was 80 ft/sec. The flowfield velocities in several cross-flow planes were measured with a 2-D, two-color LDV operated in a backscatter mode (Figure 1a). Measurements were concentrated in the secondary separation region. A typical survey is shown in Figure 1b. This survey was taken at a model location where the maximum side force occurs. This figure shows the overall character of the leeward flowfield with the influence of the two body vortices. S_a' and S_s' are attachment and separation points, respectively. Figures 1c and 1d show in more detail the characteristics of the secondary flow region. Details of the experiment are described in AIAA paper 82-0343, "The Secondary Separation Region on a Body at High Angles of Attack" by W. J. Yanta and A. B. Wardlaw, Jr. presented at AIAA 20th Aerospace Sciences Meeting, 11-14 January 1982/Orlando, Florida.

Measurements of the velocity and density flowfields in the shock-layer region of a reentry-vehicle indented nose configuration have been carried out at Mach 5. The velocity flowfield was measured with a 2-color, 2-D, forward-scatter LDV system shown schematically in Figure 2a. Because of the need to minimize particle lag in the shock-layer region, polystyrene particles with a mean diameter of 0.312 microns were used for the scattering particles. The model diameter was 6 inches. A typical LDV survey is shown in Figure 2b. It is seen that there is some particle lag in approximately the first 0.2 inches after which, the particles are in equilibrium with the flow. Separation and flow reversal are very obvious in the indented part of the nose shape thus verifying the existence of a separation region on this type of nose shape. Details of the experiment can be found in the paper "The Hypersonic Flowfield Over a Reentry Vehicle Indented Nose Configuration" by A. M. Morrison, W. J. Yanta, and R. L. P. Voisinet, AIAA paper 81-1060, presented at the AIAA Thermophysics Conference, 23-25 June 1981, Palo Alto, California.

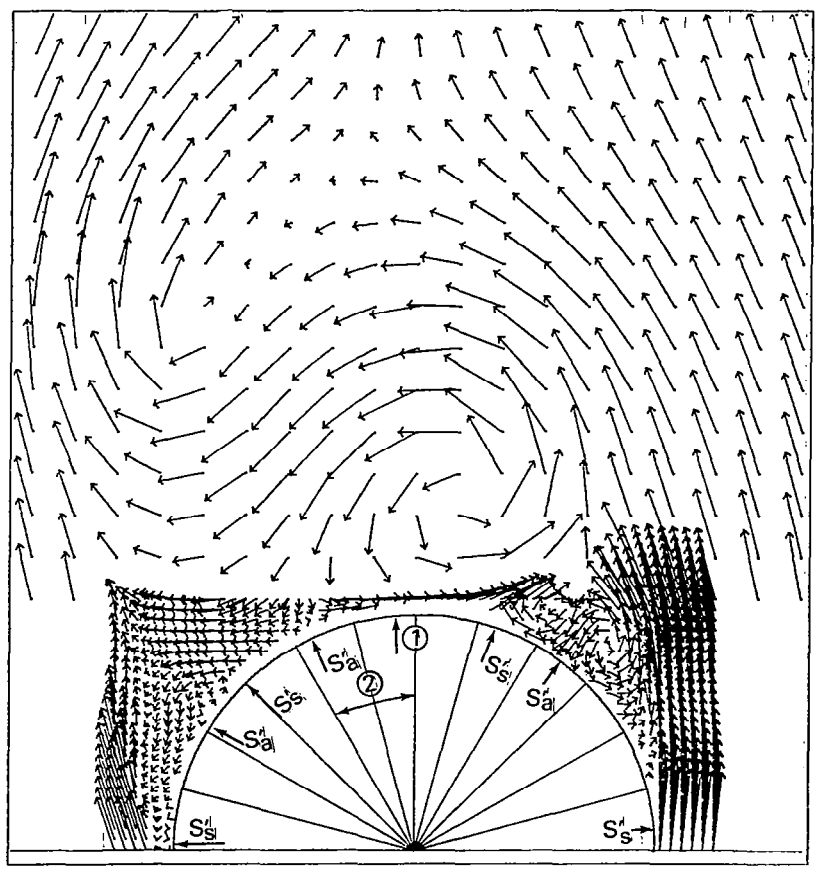
Three-dimensional velocity measurements were carried out in the boundary layer of a 7°-semivortex angle sharp cone for angles of attack of 0°, 2°, and 4° in NSWC Supersonic Tunnel 2 at a free-stream Reynolds number of 2.3×10^6/ft (7.5×10^6/m) and a Mach number of 3. The mean U, V, and W velocity components were measured for seven circumferential locations around the body at one axial station using a 3-D LDV system as shown in Figure 3a and described in Proceedings from the Seventh Biennial Symposium on Turbulence, "A 3-D Laser Doppler Velocimeter For Use In High Speed Flows," by W. J. Yanta and D. W. Ausherman, presented at the University of Missouri, Rolla, Missouri, September 1981. The system was capable of measuring the cross-flow velocity directly while still utilizing three nonorthogonal 1-D LDV components.

The development of the flow around the body at an angle of attack of 4° is shown in Figures 3b, 3c, and 3d for the U, V, and W velocity components, respectively. All velocities have been transformed into model coordinates so that U, V, and W are the velocity parallel to the model surface, velocity perpendicular to the model surface and the cross-flow velocity component, respectively. Also, all measurements have been nondimensionalized by the free-stream speed of sound. The V component is highly dependent on the circumferential position on the windward side of the model to about 135° but shows negligible change from 135° to 180°. The U velocity undergoes a larger change on the leeward side of the model. W appears to be proportional to U sin ϕ from $\phi = 0°$ to $\phi = 180°$. A more complete description of the mean velocity data can be found in AIAA paper 82-0289, "Measurements of a Three-Dimensional

Boundary Layer on a Sharp Cone at Mach 3" by W. J. Yanta, D. W. Ausherman, and E. Hedlund, presented at the AIAA 20th Aerospace Sciences Meeting, 11-14 January 1982/Orlando, Florida.

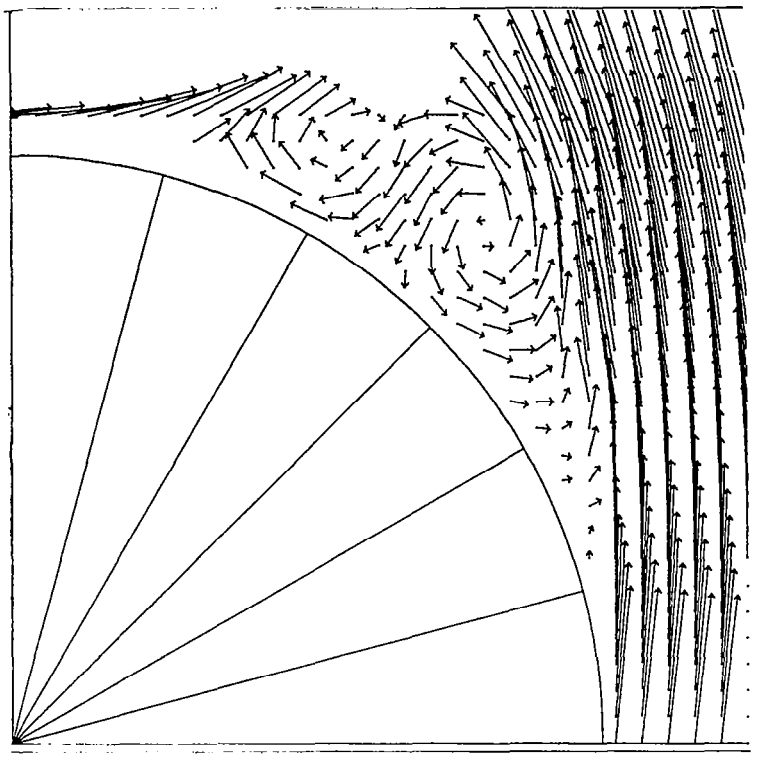


(a) 2-D backscatter LDV.

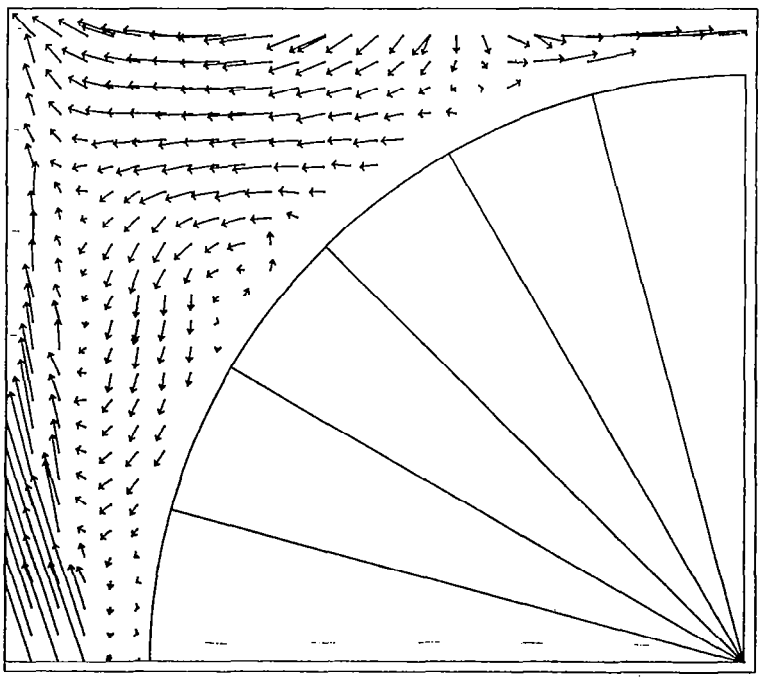


(b) Typical survey

Figure 1.- Measurements of flowfield velocities.

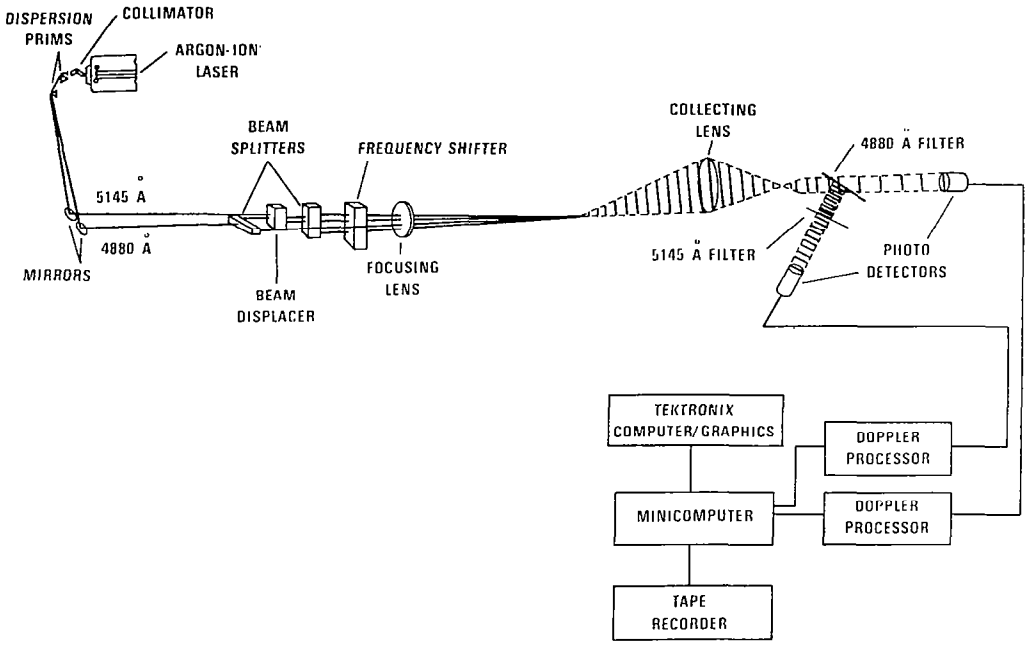


(c) Survey details, right side

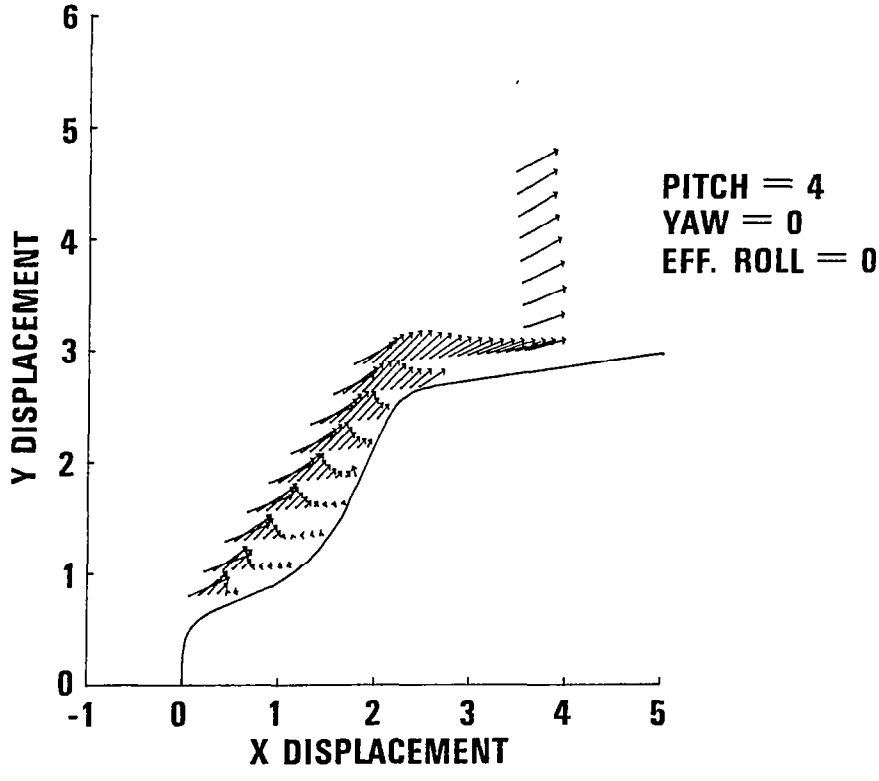


(d) Survey details, left side

Figure 1.- Concluded.

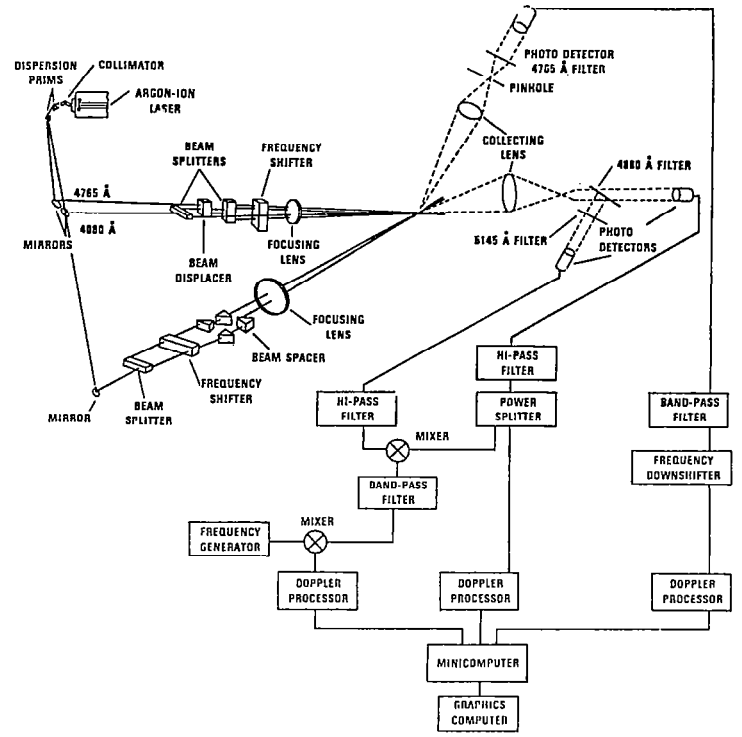


(a) Schematic of 2-D LDV

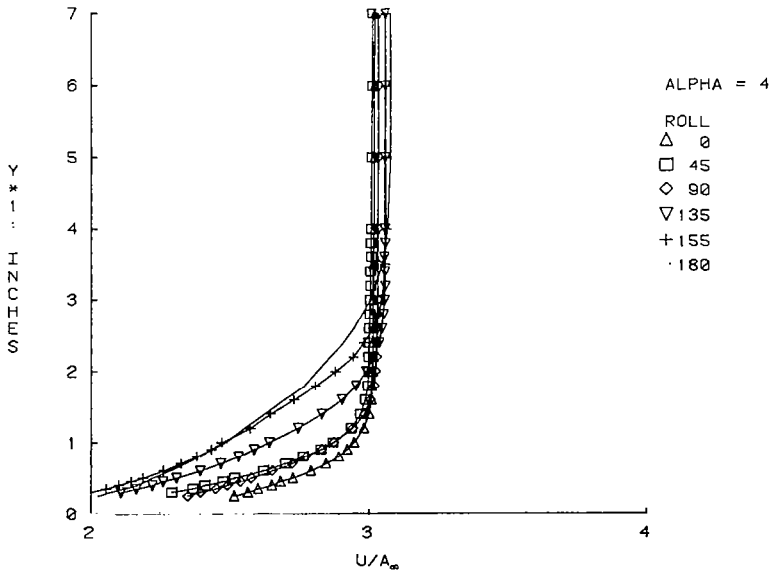


(b) Indented nose flowfield

Figure 2.- Measurements of velocity and density flowfields.

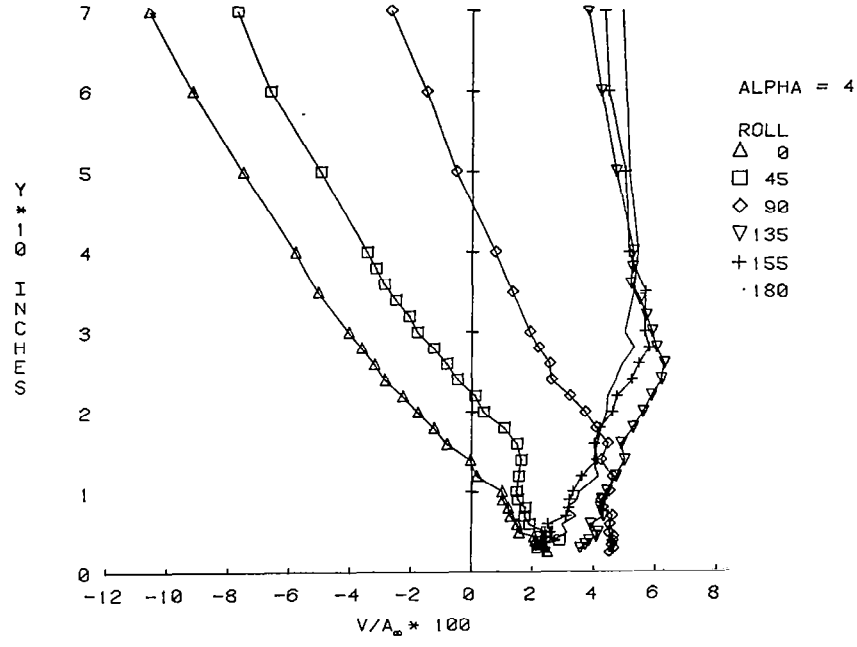


(a) 3-D LDV schematic

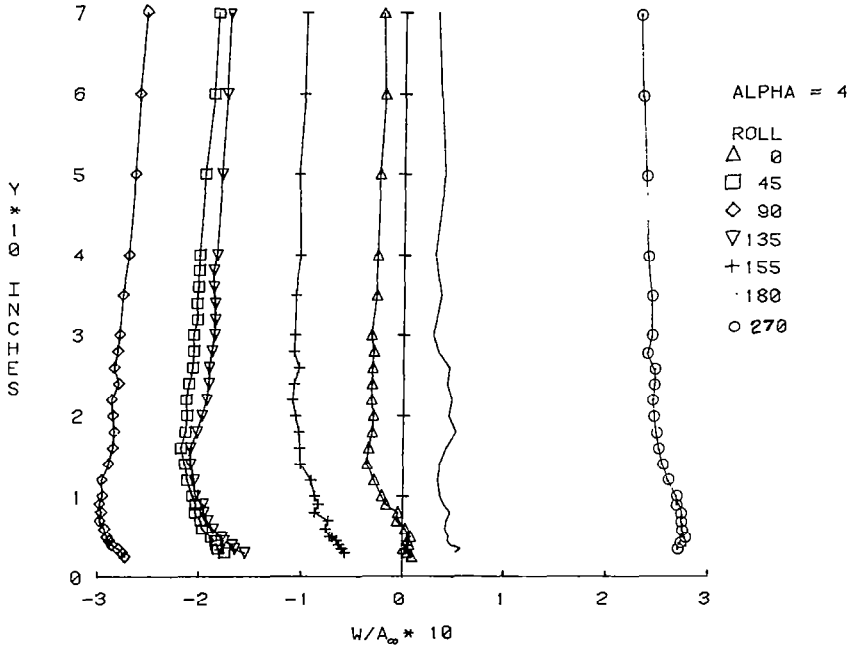


(b) U velocity component

Figure 3.- Three-dimensional velocity measurements.



(c) V velocity component



(d) W velocity component

Figure 3.- Concluded.